NASA/GSFC	NETWORKS AND MISSION SERVICES PROJECTS (N&MSP) CONFIGURATION CHANGE REQUEST (CCR)

1. CCR. NO.	2. DATE	3. PRIORITY	4. CHANGE LEVEL
CCR-451-WSC-09	April 22, 1999	☐ EMERGENCY ☐ URGENT ☒ ROUTINE	☐ A ☒ B ☐ C

5. TITLE OF CHANGE:
ICD CCRs 1-14 Ground Rules Incorporation

6. DOCUMENT TITLE: Requirements Specification for the White Sands Complex

DOCUMENT NO.: 530-RSD-WSC, Rev. 1, June 1, 1997

LIST ALL AFFECTED DOCUMENTS INCLUDING PROCEDURES: None.

7. REASON FOR CHANGE:
To incorporate all 530-ICD-NCC-FDF/WSC, Rev. 5 through DCN 01 CCR (CCRs 1 through 14) ground rule changes into the applicable sections in the WSC Specification.

8. DESCRIPTION OF CHANGE: Pages xvi (errata page), xxiii/xxiv (errata page), 5-204, 5-245, A-2, A-17 through A-22

(CONT. ON ATTACHMENT)

9. IMPACT

SYSTEM

Y	N		Y	N		Y	N	
☐	☒	SCHEDULE	☐	☒	BUDGET	☐	☒	FACILITIES
☐	☒	TESTING	☐	☒	TRAINING	☐	☒	CONTRACTOR SUPPORT
☐	☒	INTERFACES	☐	☒	SECURITY	☐	☒	HARDWARE
☐	☒	SOFTWARE	☐	☒	LOGISTICS	☒	☐	DOCUMENTATION
☐	☒	GROUND SEGMENT				☐	☒	SPACE SEGMENT
☐	☒	OTHER _____						

ORGANIZATIONAL

Y	N		Y	N		Y	N	
☐	☒	450	☐	☒	____	☐	☒	MSFC
☒	☐	451	☐	☒	____	☐	☒	JSC
☐	☒	452	☐	☒	____	☐	☒	LERC
☐	☒	453	☐	☒	____	☐	☒	KSC
						☐	☒	JPL

10. COMMENTS: None.

11. ORIGINATOR	CODE 566.0	12. SEGMENT MANAGERíS APPROVAL	CODE
Caren Corbett 505-527-7026			
SIGNATURE _____	DATE _____	SIGNATURE _____	DATE _____
13. BOARD CHAIRPERSON SIGNATURE	**DATE**	**14. BOARD CHAIRPERSON COMMENTS**	
15. BOARD ACTION		**16. ACTION REQUIRED**	
☐ Approved ☐ Withdrawn		☐ Publish Document ☐ Publish DCN	
☐ Disapproved ☐ Deferred		☐ Deviation ☐ Waiver	
_____		☐ Implement Change ☐ Other _____	

N450-1(1/14/98)

Appendix B. Data Presence Monitoring and Data Quality Monitoring Functional Requirements

Appendix C. NASCOM Formatting, Reformatting, Multiplexing and Demultiplexing Functional Requirements

Abbreviations and Acronyms

4. Demodulator setup commands.

5. Bit synchronizer setup commands.

6. Convolutional decoder setup commands.

7. Deinterleaver setup commands.

8. Data Quality Monitoring (DQM) equipment setup commands.

9. Service termination commands.

10. MA beamforming commands (MA service equipment only).

c. Tracking Service. The USS ADPE Subsystem shall generate all equipment configuration and control commands required for support of customer tracking service. These commands shall include, but not be limited to:

1. Commands to configure and reconfigure customer range and Doppler equipment.

2. Doppler reference frequency commands.

3. Service termination commands.

d. Interservice. The USS ADPE Subsystem shall generate all equipment configuration and control commands required for interservice period. These commands shall include the selection of PN code assignment 48 to modulate the forward carrier.

5.6.3.2.4 Provide Pre-Service Testing Support to the PMMS

The USS ADPE Subsystem shall generate all equipment configuration and control commands required to support the PMMS in performing pre-service testing, performance measuring and diagnostic testing. This support shall include but not be limited to:

a. From the pre-service test schedule, generate commands to configure and control USS equipment setup in accordance with the test schedule. These commands shall include but not be limited to those commands specified in Section 5.6.3.2.3 with the following exceptions:

1. DQM equipment setup commands are not required.

2. For forward service testing, the USS ADPE Subsystem shall generate commands to configure the forward service chain to receive data from PMMS instead of from the DIS, and to provide the service chain output to the PMMS.

3. For return service testing, the USS ADPE Subsystem shall generate commands to configure the return service chain to receive data from the PMMS instead of from the RF Power Divider and to provide the service chain output to the PMMS instead of to the DIS.

b. Generate commands to support the PMM ADPE Subsystem in determining the range zero set (Section 5.5.2.4) which shall be used to compensate for SGLT delays when generating customer spacecraft range measurements and determining the SGLT data delay measurement (Section 5.5.2.5).The SGLT data delay measurement is required of Danzante and Cacique only.~~.~~

5.7.2 Functional Requirements

End-to-end testing shall be capable of performing the following functions:

a. Simultaneous end-to-end testing of forward, return, and tracking services for one SSA or one MA and one KSA customer, including Shuttle. Shuttle EET services (S-Forward, S-Return, K-Forward, K-Return) shall not be required simultaneously at the same ground terminal.

b. Routing of received forward test data streams to the DIS (Danzante and Cacique only).

c. Transmission of return test data streams received from the DIS (Danzante and Cacique only).

d. Operation over a representative range of the following customer characteristics:

   1. EIRP.

   2. G/T.

e. Tuning of S-band receiver across the entire S-band range.

f. Tuning of S-band transmitter across the entire S-band range.

g. Performing necessary frequency translations.

h. Sending periodic EET equipment status messages to the Ku-band TT&C ADPE via the Ku-band TT&C service bus.

i. Reconfiguration of EET equipment in response to Ku-band TT&C ADPE control via the Ku-band TT&C service bus.

j. EET antenna EIRP calibration.

5.7.3 Performance Requirements

The EET capability shall meet the following performance requirements:

a. S-band transmitter tuning range: 2200-2300 MHz.

b. S-band maximum EIRP (circular polarization): $\geq$ 45 dBW.

c. S-band receiver tuning range: 2025-2118 MHz.

d. S-band maximum G/T: $\geq$ -10 dB/°K.

e. K-band transmitter frequency: 15,003.4 MHz.

f. K-band maximum EIRP (circular polarization): $\geq$ 60 dBW.

g. K-band receiver frequency: 13,775 MHz.

h. K-band maximum G/T: $\geq$ 21 dB/°K.

i. RF Performance parameters shall be as specified in Table 5-1 of TDRSS System Design Report, Volume I: System Design 29000-200-003-004.

A.1.3 Vector Processing Ground Rules

The Interface Control Document (ICD) between the NCC/FDF and the WSC, 530-ICD-NCC-FDF/WSC shall control the exchange and use of customer and TDRS state vectors. Implementation of the vector processing algorithms defined here shall be consistent with 530-ICD-NCC-FDF/WSC. In particular, implementation shall follow the vector processing ground rules in the 530-ICD-NCC-FDF/WSC~~. These ground rules are included for reference only in Section A.4.~~

A.2 Incorporating Vectors and Delta-T Messages into a Composite Customer Ephemeris

TDRSS customers may be supported during the course of time by a combination of vectors of all types. The purpose of this section is to define an algorithm that shall be used at the WSC to incorporate the various vector types and any Delta-T messages into a composite customer ephemeris.

A.2.1 IIRV Message Verification

Upon receipt of an IIRV, the Ground Terminal shall verify that the message contents are appropriate for use in the composite customer ephemeris. The IIRV shall contain the epoch time of the state vector (Section A.3.1) and the position and velocity components (Section A.3.2). Checksums shall be provided for the time, position, and velocity. The Ground Terminal shall verify the checksums. The OPM shall be rejected if the checksums are inconsistent with the message contents.

The NCC will generally provide state vectors with epoch times close to current time or in the future. A state vector shall be rejected by the Ground Terminal if the epoch time is earlier than receipt time by more than:

12 hours for Type 1 or 2

24 hours for Type 8.

Maneuver sequence vector types 4, 5, 6, and 7 shall be accepted with any epoch times but shall not be used to update the customer composite ephemeris if the epoch time is earlier than 6 minutes prior to receipt time.

Because free-flight vectors will be propagated by the Ground Terminal, it is necessary to ensure that propagation is physically meaningful. The position vector magnitude squared (r^2) shall be computed and the vector shall be rejected if r^2 is less than (6356 kilometers)^2 = 40398736 kilometers^2.

Vector types 2, 5, 6, and 7 shall be used only with maneuver sequences. Any vector with these types that is not part of a maneuver sequence shall be rejected.

Permanent Earth stations shall only be supported by stationary vectors from the NCC. Any state vector for a permanent Earth station that does not have a vector type 8 shall be rejected.

A.3.6 Delta-T Rotation Matrix

The Delta-T rotation matrix shall be used to adjust the vectors in the customer support ephemeris in the USS and TT&C ADPE Subsystems. Application of this matrix corresponds to a rotation about the Earth's spin axis, which is the z-axis in the MOD inertial coordinate system. The slipped position and velocity vectors $\vec{r}_s, \dot{\vec{r}}_s$ shall be obtained from the original position and velocity vectors $\vec{r}_0, \dot{\vec{r}}_0$ by

$$\vec{r}_s = D_s \vec{r}_0$$

$$\dot{\vec{r}}_s = D_s \dot{\vec{r}}_0$$

where

$$D_s = \begin{bmatrix} \cos(\omega_e t_s) & -\sin(\omega_e t_s) & 0 \\ \sin(\omega_e t_s) & \cos(\omega_e t_s) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

and where t_s = amount of the launch slip (Delta-T)
ω_e = angular velocity of the Earth as defined in Section A.3.2.

The vector epoch times shall also be changed by the addition of the slip amount t_s to the vector epoch times. Late arrival of Delta-T messages shall be accommodated by retaining the entire customer support ephemeris until the end of the customer service period. Following the application of the Delta-T rotation to the customer support ephemeris, the Delta-T message shall be discarded. The Ground Terminal shall proceed to treat the slipped vectors in the same manner it would have if no slip had occurred. Vectors arriving after the Delta-T message shall be properly referenced to the new launch time, and the Ground Terminal shall not apply the rotation to these new vectors.

~~A.4 Vector Processing Ground Rules~~

~~The following pages contain the vector processing ground rules from the 530-ICD-NCC-FDF/WSC document. They are included in this section for reference only. The 530-ICD-NCC-FDF/WSC shall be the controlling document for these ground rules. Implementation of the algorithms presented in this Appendix shall be consistent with these ground rules.~~

~~A.4.1 General Application~~

~~This section contains the ground rules and constraints that are general in nature. Before addressing the ground rules the message class codes (MCC), state vector operations messages (OPMs), and state vector types will be discussed.~~

~~Two different message class codes (10 and 15) will be accepted for state vectors OPMs (state vector messages). State vectors will be processed identically irrespective of message class code. A state vector OPM will contain one OPM header, followed by up to three sets of state vector data for a single customer.~~

The state vector types that will be processed at the WSC Ground Terminals are as follows:

VECTOR TYPE	APPLICATION	PHASE
1	Free-flight	Free-flight state vectors
2	Transition to free-flight	A type 2 vector is used only as the transition vector from maneuver sequence vectors to free-flight vectors
3		Not used
4	Ignition	Maneuver sequence state vectors
5	Burnout	
6	Reentry	
7	Launch or on-orbit	
8	Stationary	Stationary state vectors

The following general ground rules apply:

a. Except for permanent Earth Stations, customer trajectory data is used according to priority based on receipt time. For each customer, the most recently received vector, regardless of type, will be used from its epoch time forward. Previously received vectors with later epochs will not be used following receipt of a new vector with an equal or earlier epoch.

b. Free-flight (type 1-2) vectors will be rejected by the Ground Terminal if they fail syntax, check sums, or if (1) the magnitude of the position vector is less than 6356 kilometers or (2) the epoch time of the vector is more than 12 hours earlier than the time of receipt at the Ground Terminal. If a free-flight vector is rejected for any of the above reasons, a state vector reject message will be sent to NASA.

c. Except for permanent Earth stations, no stationary state vector will be propagated more than 24 hours from its epoch time. No free-flight state vector will be propagated more than 12 hours from its epoch time.

d. A single state vector OPM may contain up to three state vectors.

e. OPM classes 61, 64, and 65 will be sent to NASA without TDRSS Operations and Control Center (TOCC) operator intervention.

f. The formats for free-flight (types 1-2), maneuver sequence (types 4-7), and stationary (type 8) state vector OPMs are identical. The vector type (types 1, 2, 4-8) parameters indicate whether an OPM contains free-flight, maneuver sequence, or stationary state vectors.

g. No more than 5000 vectors received from NCC for each customer will be stored at each WSC Ground Terminal. Vectors with no future applicability will be deleted. No more

than 15,000 vectors received from NCC will be stored at each WSC Ground Terminal for all customers. No more than 72 vectors for each TDRS will be stored at each WSC Ground Terminal.

The following general ground rules apply only to permanent Earth stations.

h. The NCC will provide each WSC Ground Terminal with a list of no more than 63 permanent Earth stations. For permanent Earth stations vectors with types 1 through 7 will be rejected by the Ground Terminals.

i. For permanent Earth stations, the most recently received stationary vector will be used irrespective of epoch or receipt times. Previously received stationary vectors will not be used following receipt of a new vector.

j. There is no limit to the propagation period for permanent Earth station vectors. The permanent Earth stations vectors will be retained permanently at the Ground Terminals. Permanent Earth station vectors may be updated by the NCC at any time by use of an OPM 10 or 15.

A.4.2 Maneuver Sequences

This section addresses the ground rules that are related to the use of maneuver sequences. The formats for maneuver vector sequences are shown in Table A-6.

The following ground rules apply to maneuver sequences:

a. The time between epochs of successive maneuver sequence (types 4-7) state vectors can be variable, with a minimum of 0.5 second and a maximum of 6 minutes. The maximum number of vectors in a single maneuver sequence shall be 800.

b. A maneuver sequence must include at least seven state vectors. The required seven state vectors are as follows:

State Vector		1	2	3	4	5	6	7
Vector Type	Launch or on-orbit sequence	4	7	7	2	7	7	5
	-or-							
	Reentry sequence	4	6	6	8	6	6	5
Epoch		t_1	t_2	t_3	t_4	t_4	t_5	t_6

where $t_6 = t_4 + 6$ minutes

Table A-6. Maneuver Vector Sequence Formats

STATE VECTOR NUMBER	VECTOR TYPE	VECTOR EPOCH
1	4	t_1
2	7 (6)	t_2
•	•	•
•	•	•
•	•	•
n	7 (6)	t_n
n +1	2 (8)	t_{n+1}
n +2	7 (6)	t_{n+1}
•	•	•
•	•	•
•	•	•
n + m	7 (6)	t_{n+m-1}
n + m + 1	5	t_{n+1} + 6 min.

NOTES

1. ALL MANEUVER SEQUENCES WILL HAVE THE ABOVE FORMAT.
2. THE MANEUVER SEQUENCE THAT INCLUDES THE TYPE 6 AND TYPE 8 VECTORS WILL BE USED FOR REENTRY ONLY.
3. THE VECTOR EPOCH TIME t_{n+1} IS THE END OF THE MANEUVER (TYPE 2 VECTOR) OR THE REENTRY (TYPE 8 VECTOR). THE SUBSEQUENCE VECTORS IN THE MANEUVER SEQUENCE ARE SUPPLIED TO PROVIDE TIME FOR THE IMPLEMENTATION OF THE TYPE 2 AND TYPE 8 VECTORS.
4. ONLY THE 4800-BIT BLOCK CONTAINING THE TYPE 4 VECTOR OF A MANEUVER SEQUENCE WILL HAVE THE ACKNOWLEDGMENT BIT SET IN THE REAL-TIME MODE.

c. Between transmission of the type 4 vector of a maneuver sequence and the type 5 vector of that sequence, only those vectors in the sequence should be transmitted. For a customer in the real-time mode, receipt of any other vector for any customer SIC will result in WSC Ground Terminal generation of a type 2 or 8 vector (as appropriate) and a type 5 vector to terminate the sequence. For a customer not in the real-time mode, receipt of any other vector for any customer SIC will result in the rejection of the entire sequence.

d. A type 2, 6, or 7 vector will be rejected if it is not received as part of a maneuver sequence. For customers in the real-time mode a maneuver sequence received without a

type 2 or 8 vector will be used as received and the WSC Ground Terminal will generate a type 2 or 8 vector (as appropriate). For customers not in the real-time mode, a maneuver sequence received without a type 2 or 8 vector will be rejected.

e. No reasonableness checks or gross validity checks are made for maneuver sequences. Syntax checks and checksum verification are performed for maneuver sequences.

A.4.3 Delta-T Applications

This section addresses the ground rules and constraints that are related to the use of Delta-T OPMs to shift the epoch times of maneuver sequences and other vectors that are in place at the Ground Terminal. The epoch shifts are applied to vectors in an Earth-fixed, rotating coordinate system. The purpose of the Delta-T function is to adjust for any launch slips that occur during the launch phase of Shuttle missions.

There are several important terms associated with the use of the Delta-T OPM function that need to be defined. These are as follows:

a. The Delta-T adjustment (ΔT) in the Delta-T OPM is the change in the current epoch times of the vectors.

b. The original epoch of a vector in the Ground Terminal is the epoch of the vector as transmitted to the WSC Ground Terminal.

c. The current epoch of a vector in the Ground Terminal is the original epoch of the vector plus the sum of all Delta-T adjustments (ΔT) received at the WSC Ground Terminal.

The following ground rules apply to the use of Delta-T OPMs:

a. Application of a Delta-T OPM does not change any SHO start or stop times.

b. The Delta-T adjustment (ΔT) is always calculated from the current epochs of the vectors because Delta-T adjustments are cumulative.

c. A Delta-T OPM must be received at the Ground Terminal at least 30 seconds prior to launch to ensure application. Delta-T OPMs arriving later will be applied as soon as possible.

d. A series of Delta-T OPMs may be sent for a given customer. They will be applied successively as they arrive.

e. Delta-T adjustments may be positive (delay) or negative (advance), but the absolute value of the Delta-T adjustment must be less than 12 hours.

f. The Delta-T adjustment will be applied to all vectors that are in place at the receipt time of the Delta-T OPM. It will not be applied to vectors subsequently received at the WSC Ground Terminal.

g. A Delta-T OPM transmitted between transmissions of the type 4 and type 5 vectors of a maneuver sequence for any customer will result in rejection of the maneuver sequence.

A.4.4 Real-Time Mode

This section addresses the ground rules that are related to operations in the real-time mode at the Ground Terminal.

a. A customer will enter the real-time mode upon receipt of any of the following messages less than 6 minutes prior to the start of service or during service.

   1. Delta-T message.

   2. Type 1 or 8 vector with an epoch prior to the end of service.

   3. Type 2, 4, 5, 6, or 7 vector as part of a maneuver sequence and with an epoch time in the future and prior to the end of service. Real-time maneuver sequence support will not begin until there are at least two maneuver vectors at the WSC Ground Terminal with epoch times in the future.

b. The customer will remain in the real-time mode until completion of updating of the customer ephemeris. This will generally be within 30 seconds of receipt of the OPM. (Receipt of multiple Delta-T OPMs may delay implementation.)

c. The Ground Terminal will notify NASA when a customer enters and exits the real-time mode.

d. Acknowledgment of all blocks of a maneuver sequence shall be requested if the epoch of the type 4 vector is more than 7 minutes later than start of transmission. If the epoch of the type 4 is less than 7 minutes later than start of transmission, only the block containing the type 4 vector shall request acknowledgment.

e. There can only be one real-time customer per SGLT at any given time.

f. Once maneuver sequence support in the real-time mode has begun, if current time passes the epoch of the last maneuver sequence vector at the Ground Terminal , the remainder of the sequence will be rejected and maneuver sequence support will be terminated.